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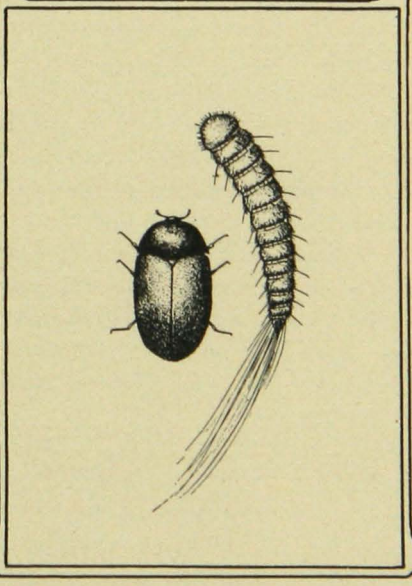
Chlorpicrin
New Fumigant for Mill and Household Insects

by

A. L. Strand



The Black Carpet Beetle and Larva
A common household insect very difficult to control.

UNIVERSITY OF MINNESOTA
AGRICULTURAL EXTENSION DIVISION

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METHODS FOR THE APPLICATION OF CHLORPICRIN AS A FUMIGANT FOR FLOUR MILL AND HOUSEHOLD INSECT PESTS

Part 1. For Fumigating Flour and Cereal Mills
Part 2. For Fumigating Upholstered Furniture
Part 3. As a General Household Fumigant

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Introduction

Of the many different chemicals and combinations of chemicals whose destructive action on insects has been investigated during the last few years, none has shown more promise than chlorpicrin. The qualities that have attracted attention to this substance are its ability to penetrate materials, the shortness of time required to kill, and the effectiveness over a wide range of temperatures. As it is non-explosive and non-inflammable, its use in mills and elevators does not invalidate insurance, but on the contrary is approved by the fire underwriters.

Altho chlorpicrin is not poisonous to man in the sense that hydrocyanic acid is, it is extremely irritating to the eyes and the respiratory passages. On account of this irritation and the slow rate at which the liquid chlorpicrin evaporates, means for applying it are of primary importance. There is no question as to its ability to kill, but a problem is presented in getting the liquid into the gaseous state within the space to be fumigated without inconvenience or hazard to the persons handling it. Methods of application by which this can be accomplished are described in this circular.

On Chlorpicrin in General

Chlorpicrin, or nitro-chloroform, is a heavy, colorless, or slightly yellowish liquid (specific gravity 1.67 to 1.69) which volatilizes rather slowly. The gas formed is about five times heavier than air and where there is no interference to its movement it settles rapidly. That is, if there are low openings in a room or bin through which the gas can escape, it will flow out almost like water, but if the gas is confined it diffuses about equally throughout the entire space. On account of the heaviness of the chlorpicrin vapor, the stairways of a house being fumigated must be closed off or the concentration of the gas will not be maintained long enough on the upper floors to secure good results. In fumigating bins and elevator legs in a mill, the material should be applied at the top.

Chlorpicrin adheres strongly to many dry materials. This is both an advantage and a disadvantage. Because of this adsorption and the heaviness of the vapor, it has a marked penetrating power and can reach many insects which are more or less protected from the action of some other fumigants. As a result chlorpicrin has been found to be especially effective against the larvae of clothes moths working beneath the fabric of upholstered furniture, against the black carpet-beetle larvae which like to dwell in cracks of floors where they are protected by dust and dirt, and against insects infesting stored food products. However, because of the adsorption of chlorpicrin, it is difficult to get rid of the gas after a fumigation, but it can be removed by thoro airing.

The irritating effect of chlorpicrin on man is also an advantage. One unfamiliar with the odor of hydrocyanic acid might possibly stay long enough in a room in which the gas is present to be overcome and killed by it, but with chlorpicrin this would never happen. The effect on the eyes of even a low concentration warns a person long before there is any danger from breathing the fumes. Liquid chlorpicrin, should it accidentally be spilled on the hands, causes the skin to feel dry but does not burn or cause slowly healing sores. Statements concerning such results are, in our experience, entirely without foundation.

How Chlorpicrin Should Be Handled

In transferring chlorpicrin from large containers in which it is received from the factory or jobber to containers of more convenient size, and in filling atomizers or other equipment in which it is to be used, the operation should be carried on in the open air. This obviates any discomfort from small amounts which might be spilled and makes the use of a gas mask unnecessary. If a slight breeze is blowing and the person doing the work keeps to the windward side, the material can be handled with little or no inconvenience. Do not smell at the mouths of bottles or other containers in which the liquid may be stored, as air which is completely saturated with chlorpicrin is a powerful irritant when drawn into the lungs.

Why Chlorpicrin is Used in Combination with Carbon Tetrachloride

Chlorpicrin evaporates very slowly, as indicated by its rather high boiling point, 112° C. (233.6° F.), in contrast with 76° C. (168.8° F.) for carbon tetrachloride and 46.2° C. (115° F.) for carbon disulphide. In order to overcome this low volatility and hasten the operation of getting the material from the liquid state into the gaseous state, Dr. R. N. Chapman, of the Minnesota Agricultural Experiment Station, began the use of a mixture of chlorpicrin and carbon tetrachloride.

It was found that the best results were obtained with a mixture of equal parts by volume of the two liquids. This mixture evidently has a higher vapor pressure than chlorpicrin alone and as a result evaporates faster. The advantage of using the mixture is increased many fold when it is to be applied with atomizing sprayers.

It should be found out, when the chlorpicrin is bought, whether it has been diluted with carbon tetrachloride. That fact should be borne in mind in connection with the following directions.

PART I. USE OF CHLORPICRIN FOR FUMIGATING FLOUR AND CEREAL MILLS

Until chlorpicrin came into use as a fumigant there was nothing which could be used safely in a mill to combat localized infestations of insect pests. Such infestations, therefore, have usually gone uncared for until large enough to necessitate the fumigation of the whole mill. Mills in which conditions forbid general fumigations with hydrocyanic acid, have had to resort to frequent thoro cleansings which make necessary the shutting down of all or part of the equipment. Chlorpicrin has been found to be an effective agent for fumigating at regular intervals the mill machinery most liable to be infested. By its use, the number of general fumigations can be greatly reduced.

Advantages of Chlorpicrin as a Mill Fumigant

In a flour mill of 150 barrels capacity per day there are roughly speaking only 3250 cubic feet of space inclosed within the actual milling machinery, not including any large storage bins. It is within part of this comparatively small space that infestations first develop and clog spouts and machines. The amount of such a fumigant as chlorpicrin which can be applied to the inside of the machinery, therefore, is so small that the low cost makes it possible to apply it at frequent regular intervals. On the other hand, to house the machinery of a 150-barrel mill, from 75,000 to 100,000 cubic feet of space is required. Not only is this space, which must be treated in a general fumigation, many times as great, but the insects missed are very often the ones inside the machines and elevator legs, where they multiply rapidly and are soon back to their original numbers. While in many general fumigations with hydrocyanic acid the poorest results are obtained inside the machinery and the best results outside, in chlorpicrin fumigations the best results are obtained inside the machinery where the greatest benefits will accrue.

The machines, elevators, and conveyors which carry the low-grade streams seem to be the principal places of infestation of the Mediterranean flour-moth larvae. If these are fumigated with chlorpicrin, and the treatment is repeated every two weeks, the insects can be kept down to a point where their numbers are negligible. Prevention, in the case of this insect, is highly desirable. Once a flour-moth infestation has enlarged to such an extent that the machinery is clogged and a general fumigation is necessary, there is in addition the tedious task of cleaning up, which, in point of labor and operating time lost, may be more expensive than the cost of the general fumigation itself.

The chief advantage of chlorpicrin is that infestations need not be allowed to reach the stage where fumigation is absolutely essential. Under the prevailing system of cyanide fumigations, in nine cases out of ten the infestations reach their absolute maximum before fumigation is resorted to. When chlorpicrin fumigations are carried out regularly, the number of insects is kept down to a minimum at about the same cost for labor and materials as would be expended on general fumigations. In many mills the cost would be less.

Where Chlorpicrin Can Be Used in a Mill

Chlorpicrin can be used (1) in all closed machines, or machines capable of being made tight, such as bolters, purifiers, and grinders; (2) in dusters which are constructed in such a way that they will hold the gas; (3) in storage bins, and (4) in conveyors and elevator legs.

How Chlorpicrin is Applied

The best method yet developed for applying chlorpicrin in mill fumigation is with the apparatus shown in Figure 1. This consists of atomizers[1] operated by air or oxygen from a pressure tank. The proper amount of the chlorpicrin-carbon tetrachloride mixture is put in each atomizer. This should be done out of doors. Then an atomizer is set in each elevator head, as shown in Figure 2. The heads on elevators known to be infested or leading to machines which are infested may be selected for fumigation, or an atomizer may be placed in each elevator head and a whole section of elevators and machines treated at one time. The latter is perhaps the better practice. After the atomizers are placed they are all connected to an auxiliary pressure tank with a pressure gauge which in turn is connected with the pressure tank. If the mill is equipped with air pressure this can be used to operate the atomizers by connecting a convenient air line to the auxiliary tank. Hand pumps are not satisfactory when more than three

[1] The atomizers which we have used are known as "continuous sprayers." They were modified somewhat by the removal of the hand-pump attachment. The containers of the atomizers should be of brass so that they will not be corroded by the chlorpicrin.

or four atomizers are connected together. If so desired, a gauge can be attached to the tank of compressed gas which registers both the pressure in the tank and the pressure being delivered at the outlet. This would eliminate the auxiliary tank.

When everything is in readiness and the mill has been allowed to run empty or nearly so by shutting off the supply of grain and **while the machinery is still running,** the pressure is turned into the atomizers. The chlorpicrin vapor is thus circulated throughout all the elevators and machines which have been connected. A pressure on the atomizers of about 15 pounds should be maintained. As soon as the

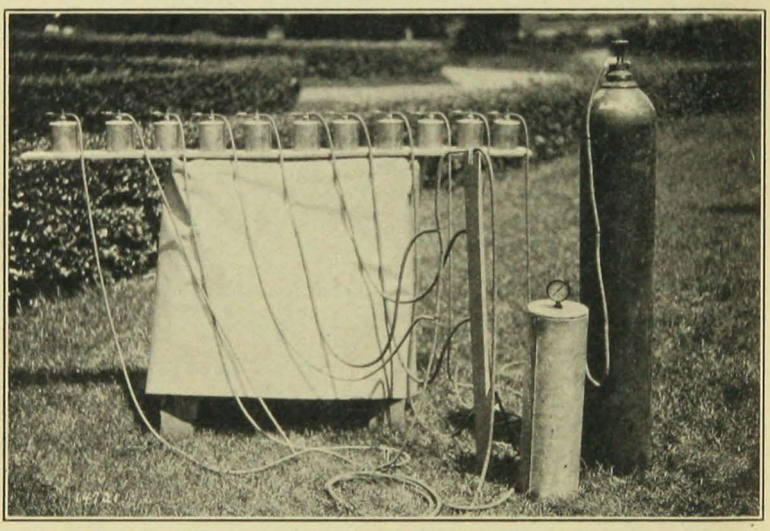

Fig. 1. Apparatus Used in Applying Chlorpicrin Within the Milling Equipment of Flour and Cereal Mills, and as a General Household Fumigant

material has been applied, the mill is shut down and allowed to remain so from six to twelve hours. Then the machines and elevator legs can be opened and allowed to air.

When the mill is started again after a chlorpicrin fumigation it is a good practice to take off several of the first sacks of flour which come through. These can be mixed with the feeds or they can be fed back slowly into the mill. The small amount of chlorpicrin adsorbed by the flour will be dissipated when it is mixed with a large amount of unfumigated stock. If regular chlorpicrin fumigations are to be employed in a large mill, it would be well to take off several sacks of flour after the first fumigation and note their order of coming through the mill. By making baking tests, the extent to which the different sacks are affected can be determined. In later fumigations just enough flour need be removed to insure getting that whose baking qualities have been

affected. Very small quantities of chlorpicrin can be detected during the baking process by the odor of the gas given off. It has been shown that flour treated very intimately with chlorpicrin will recover its original baking qualities if it is aerated for sufficient time. If the mill is allowed to run empty before the chlorpicrin is applied and if all parts of the machinery are given time to air thoroly afterward, less flour need be removed.

Fumigation of Storage Bins

The atomizer method works well when the cubic capacity of the space to be fumigated is not too large, but when large bins are to be treated another method must be employed. Either an atomizing pump of considerable capacity can be used or the chlorpicrin can be poured directly

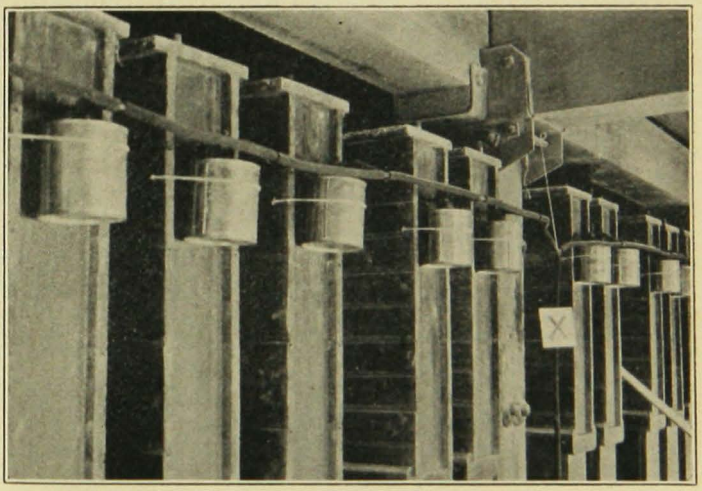

Fig. 2. Atomizing Sprayers Set in the Elevator Heads of a Flour Mill

A one-hole stopper on each atomizer stem fits very tightly into a hole of correct size bored into the elevator head. The air line shown at X runs to a pressure tank and auxiliary tank as illustrated in Figure 1.

on sacks hung through the top openings of the bins. In the latter case the amount of material to be applied to each bin should be measured into a wide-mouthed bottle, from which it can be poured rapidly onto the sacks. The openings to the bins should be closed tightly just as soon as the liquid has been applied. The bins or tanks fumigated should be empty at the time, as it would be difficult to air the fumigated material long enough to rid it of the chlorpicrin.

Best Time for the Fumigation

The best time to fumigate with chlorpicrin is when the mill is closed down on a Saturday. The next day the machines can be opened and the mill aired to be ready for operation again Monday morning without

loss of ordinary operating time. In mills which do not close down over Sunday the fumigation period can be reduced to six hours. With from three to six hours for airing, the total shut-down period need not be more than twelve hours.

Amounts of Chlorpicrin Which Should Be Used

One pound of chlorpicrin to 1000 cubic feet of space has killed 100 per cent of the Mediterranean flour-moth larvae in tight elevator legs. This amount is not sufficient, however, to kill the confused flour beetles, which are very resistant to all fumigants. Consequently, it is recommended that five pounds of chlorpicrin to 1000 cubic feet of space be used when the material is applied at the elevator heads according to the method described. This amount is excessive, but an excess is required in order to make sure that a killing strength has been carried to the most remote of the machines and conveyors. Even with such a high concentration, when the cubic contents of the elevators and machines are figured very liberally the amount of material to go in each atomizer is not large.

Table 1.—Chlorpicrin Dosage Schedule for Flour and Cereal Mill Fumigations

Capacity	Machines and elevator legs		Bins and tanks	
cu. ft.	cc.	fl. oz.	cc.	fl. oz.
100	134	4.7	54	1.9
200	268	9.5	107	3.8
300	402	14.2	161	5.7
400	536	18.9	215	7.6
500	670	23.7	268	9.5
600	805	28.4	322	11.4
700	939	33.1	376	13.3
800	1073	37.8	429	15.2
900	1207	42.6	483	17.1
1000	1341	47.3	536	19.0
1100	1476	52.0	590	20.9
1200	1610	56.8	644	22.8
1300	1744	61.5	698	24.7
1400	1878	66.2	751	26.6
1500	2012	71.0	805	28.5
1600	2146	75.7	858	30.4
1700	2280	80.4	912	32.3
1800	2414	85.1	966	34.2
1900	2548	89.9	1020	36.1
2000	2683	94.6	1073	38.0
2500	3354	118.3	1341	47.5
3000	4025	142.0	1610	57.0

In tight bins and tanks, two pounds of chlorpicrin per 1000 cubic feet of space is sufficient. A concentration greater than this does not decrease the time necessary to kill the insects enough to be worth while. Also, the less that can be successfully used in such places the better, for less time will then be required for airing.

Table 1 gives the correct amounts of undiluted chlorpicrin in cubic centimeters and fluid ounces to be used (1) in the machines and elevator legs, and (2) in bins and tanks. In each case a like volume of carbon tetrachloride should be added.

Prevention of Leakage

It is essential that the equipment being fumigated be tightly enough constructed to confine the gas. Altho chlorpicrin will kill in a much shorter time than even heavy doses of carbon disulphide, the time is not so short that good results can be obtained where there is much leakage of the gas. Consequently, for a successful fumigation it is just as necessary to spend time insuring that all machines, elevators, and bins are made as tight as possible as it is to apply the fumigant itself. The elevator heads should be made to fit well and the packing around the shaft should go all the way around and be fairly compact. Any loosely fitting elevator boots should be repaired and cracks along the walls of the elevators should be closed with putty or sealed with cloth put on with liberal amounts of flour paste. Strips of gummed paper or adhesive tape can be used to close cracks about the machines.

Modifications of the Method

The method given may be modified to suit particular needs. If infestations persist in just a few machines, elevators, or conveyors, these can be shut off from the rest of the mill by plugging the spouts which lead to and from them (particularly the lower openings) and given special attention. Holes can be bored for the accommodation of an atomizer in each machine, and a hand tire pump can be used to operate the atomizer. In the conveyor boxes beneath rebolt reels, which are sometimes badly infested with flour beetles, or in horizontal conveyors anywhere in the mill, sacks can be laid in one or two places, according to the length of the conveyor, and the chlorpicrin-carbon tetrachloride mixture poured directly on them. This can be done after the mill is closed down at night and the sacks be removed the following morning. In this method of application, a gas mask should be worn when the sacks are removed, particularly if the places fumigated are rather inaccessible.

Good results have been secured when the operator wears a gas mask and applies the chlorpicrin by means of a small hand sprayer. The liquid is directed through small openings into the upper parts of infested machines, for instance, through the small sliding doors at the tops of grinding rolls, where the spouts lead in. The hand sprayer can be used to supplement the first method described in which an atomizer is used in each elevator head and the mill is operated during the application. If a little chlorpicrin is sprayed into the machines just before applying

the mixture at the elevator heads, it is especially beneficial in cleaning up heavy infestations when regular chlorpicrin fumigations have not been carried out. In treating grinding rolls with a sprayer, care should be taken that the liquid is not directed against the rolls themselves, which might be rusted by it.

Without any doubt many other ways of using chlorpicrin in a mill can be worked out by millers who understand its properties. A substance which so readily destroys insect life should find an important place in the operation of flour and cereal mills. We believe it is only a matter of time until it comes into very general use as a mill fumigant.

PART 2. USE OF CHLORPICRIN FOR FUMIGATING UPHOLSTERED FURNITURE

Upholstered furniture is often severely damaged by the larvae of clothes moths. The recent popularity of furniture covered with mohair has brought an increased number of complaints of such damage not only from householders but from furniture dealers and manufacturers as well. As the results of ordinary hydrocyanic acid fumigations of such infested furniture were not very consistent, the development of a more adequate control measure was very desirable. The high toxicity of chlorpicrin to insects, its penetrating ability, and the fact that it has no bleaching effect upon fabrics, seemed to give it the necessary qualities for this purpose. As a number of fumigations of badly infested furniture with chlorpicrin have proved entirely effective, directions are given here for its application in order that it may come into more general use.

Owing to some of the properties of chlorpicrin, which have already been pointed out, its use for the treatment of infested furniture may be limited somewhat to concerns making a business of fumigating. This is not necessarily true, however. The equipment for applying the liquid costs but little and if a tight room, such as a well built garage, is available, a successful fumigation can be carried out by any careful person who follows the directions given in this circular.

Character of the Damage to Furniture Caused by Clothes Moths[2]

The damage to the furniture is caused by the larvae, which eat the mohair threads on the underside of the cloth where they are brought through and around the woof. This releases the nap and allows it to fall off, thus leaving bare spaces where only the foundation cotton threads of the fabric remain. Because the foundation threads, which are not attacked by the larvae, are usually bright red or yellow, the damaged areas stand out very prominently when devoid of the darker colored

[2] The species of clothes moth concerned here is the web-spinning clothes moth, *Tineola biselliella* Hummel.

nap. Figure 3 shows a piece of mohair cloth removed from a badly infested chair. The larvae are seldom seen on the outside; the falling off of the nap usually first reveals their presence. They remain just beneath the fabric, between it and the padding of cotton or flax composition. Altho the larvae may be present at any time of the year, the greatest damage occurs between April and June and between August and October.

Methods for Application of Chlorpicrin to Infested Furniture

In developing a convenient way to treat upholstered furniture with chlorpicrin, several different methods have been used with equally good success. From the standpoint of practicability the earlier methods tried have all given way to the use of atomizers, as described for the treatment of mill insects. However, as two of these less practical means of application may be useful, they will be described briefly, but the third and last method given is believed to be the most satisfactory under most conditions.

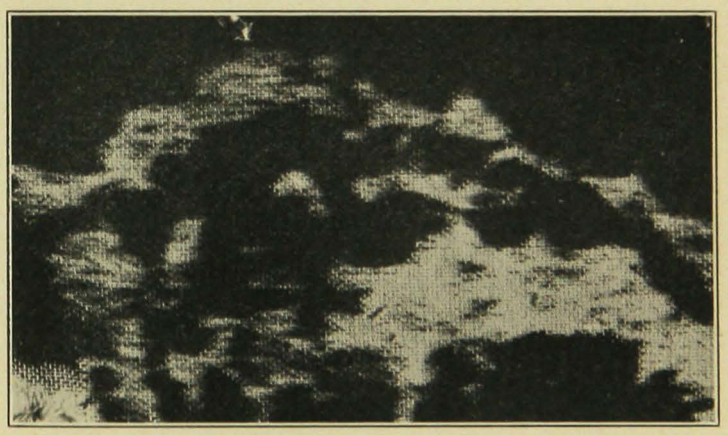

Fig. 3. Mohair Upholstering Cloth Damaged by the Larvae of the Web-Spinning Clothes Moth

1. **Application of chlorpicrin by means of air pressure into a regularly equipped fumigation room.**—The first method was designed to be used in a room equipped for regular fumigation work. There has been some demand for the plan of such a room as shown in Figure 4 and in actual practice this arrangement has worked very well. The compressed air tank should be stout enough to hold more than 100 pounds pressure. It can be filled with air by means of either a small motor driven pump or an automobile tire pump. From the compressed air tank a pipe leads to the chamber in which the chlorpicrin is placed. This chamber is so constructed that when the air is turned on from

the pressure tank the liquid in the chamber is forced out through the one-eighth inch pipe leading to the nozzles. A disk type nozzle with an aperture of one thirty-second of an inch is used. As liquid chlorpicrin rusts iron with which it comes in contact, the chamber used to hold the chlorpicrin, the piping, and the nozzles should be of brass.

The furniture should be so placed in the room that the spray from the nozzles will not strike it, otherwise too much of the liquid would be applied to one part of a piece of furniture and require a long time to air out. Even when the nozzles are ten feet from the floor and very small aperture disks are used in them, not all the chlorpicrin-carbon tetrachloride mixture will volatilize before it reaches the floor. If a screen of cloth or paper is suspended horizontally beneath the nozzles and about three feet from the floor, the unevaporated liquid falling upon it will evaporate from such a surface much quicker than from the floor.

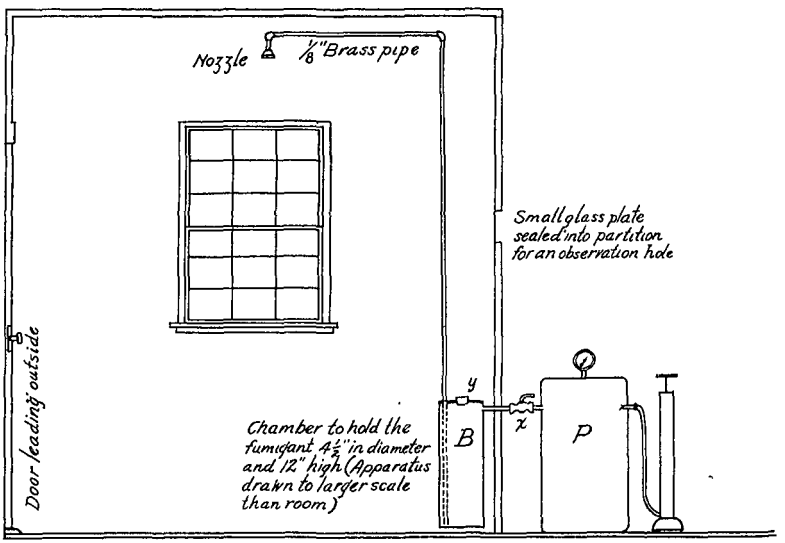

Fig. 4. Diagram of Fumigation Room Equipped for Applying Chlorpicrin

The best order of procedure in using this method is as follows:

1. Place the furniture where the spray from the nozzles will not strike it.

2. Pump air into the pressure tank until a pressure of about 90 pounds has been attained. Make sure that the valve at x (Figure 4) is not leaking.

3. Put the correct amount of the chlorpicrin-carbon tetrachloride mixture into the chamber B, and replace the threaded plug, y.

4. Close the door to the fumigation room and stop up any cracks around it with wet newspaper.

5. Turn on the valve, x, which will allow the air from the pressure tank to force the liquid from the chamber, B, out through the nozzles.

6. As soon as all the liquid has been forced into the fumigation room, turn off the air from the pressue tank.

Allow the room to be closed for twelve hours. Then open the door and window and in two or three hours the furniture can be removed.

2. **Hand-operated sprayer method.**—In the second method a hand-operated compressed-air sprayer is used and the operator is protected by a gas mask. This method has some advantages over the others, especially if the furniture is heavily infested. The liquid is sprayed directly on the upholstering. In several experiments performed in a room of 1300 cubic feet capacity, 2.6 pounds of chlorpicrin has been sprayed on a large davenport and two chairs without the slightest damage to the fabric and with little extra time being required for airing. A high concentration of the gas is secured where it will do the most good and particular attention can be paid to parts of the furniture which seem to be most heavily infested. Both army and navy types of gas masks, worn during many experiments upon which these recommendations are based, proved satisfactory.

Good success has also been secured in treating furniture by this method when only a small amount of the chlorpicrin-carbon tetrachloride mixture was used (one-half pound of each). This was applied directly to the upholstering, the furniture being then covered with two thicknesses of a heavy duck tarpaulin and left for twelve hours. This treatment must be carried out, however, in a moderately tight room. Figure 5 shows a gas mask and small sprayer suitable for this method.

3. **Atomizer method as applied to the treatment of upholstered furniture.**—This is a comparatively simple means of application and it is believed to be the best yet developed. A tightly constructed garage or other outbuilding can serve as a fumigation room. The atomizing sprayer used is the same as the one shown in Figure 1, except that the special cap is used which directs the spray upward at an angle of about sixty degrees instead of straight ahead. Several of these atomizers can be used, the number depending on the size of the space to be fumigated. They should be placed on a shelf at one side of the room and three or four feet above the floor. As the containers of the atomizers hold about a quart of liquid, one atomizer is sufficient for one pound of chlorpicrin and an equal volume of carbon tetrachloride. When two or more are used they can be connected to one air line by means of T tubes. The tubing which carries the air pressure to the apparatus can be run through a small hole bored in a door or window frame. A

tank of compressed air or a double-action tire pump can be used to operate the atomizers. A pump is not satisfactory when there are more than three or four atomizers. If several fumigations by this method are to be carried out, it might be worth while to obtain a stoutly built tank of five or ten gallons capacity and fit it with a stop-cock and ordinary tire valve. The tank could be pumped up to a pressure of 75 to 100 pounds and the stop-cock used to release this pressure fast enough to supply the atomizers. Whether a pressure tank or a pump is used, this part of the apparatus should be stationed just outside a window of the fumigation room so that the operator can observe how the atomizers are working and when all of the material has been applied.

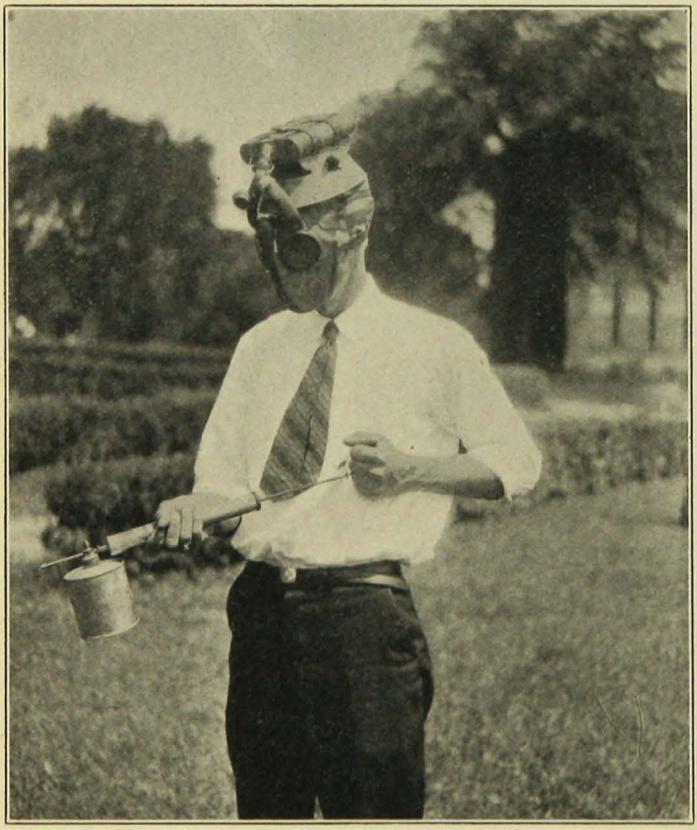

Fig. 5. Gas Mask and Atomizing Sprayer Used to Apply Small Amounts of Chlorpicrin

The sprayer shown here is the same as illustrated in Figures 1 and 2 except that the hand pump has not been removed.

After the furniture has been placed in the fumigation room and that part of the apparatus within the room is ready for action, the doors and windows and any other places where the gas could escape should be sealed. Then the air from the pressure tank can be turned on or the pump operated until the atomizers are empty. The fumigation, as under the other methods, should be allowed to continue for twelve hours.

Dosage of Chlorpicrin Necessary to Kill Clothes Moths in Upholstered Furniture

Two pounds of chlorpicrin should be used for each 1000 cubic feet of space in the room in which the furniture is to be treated. The required quantity of chlorpicrin should be diluted with an equal volume of carbon tetrachloride. In case the hand sprayer and gas mask method of application is adopted, the chlorpicrin, if desired, can be applied without dilution. This would reduce the time necessary for the operator to be in the room. The required amounts of chlorpicrin for rooms of different sizes can be determined from Table 1. The concentrations given under "Bins and Tanks" are the same as for the fumigation of furniture.

PART 3. USE OF CHLORPICRIN AS A GENERAL HOUSEHOLD FUMIGANT

Chlorpicrin has been found to be very effective for the fumigation of dwelling houses. It is perhaps the most efficient substance which can be used to rid a house of such insects as carpet beetles and clothes moths. The results of hydrocyanic acid fumigations against the black carpet beetle are not always satisfactory even in very tightly constructed houses. Many of the larvae, protected by dust and dirt in the cracks of the floors, escape the treatment. Chlorpicrin will penetrate to such larvae and hence a much better control of the insects is effected.

Application of Chlorpicrin in Dwelling Houses

The same apparatus described for use in flour mills has been successfully adapted for dwelling houses. The atomizer caps which direct the spray upward are used in order that less unevaporated liquid will fall to the floor. Enough atomizers are distributed throughout the house to hold the required quantity of the chlorpicrin-carbon tetrachloride mixture. As the concentration used in the fumigation of houses is a pound and a quarter of chlorpicrin to each 1000 cubic feet of space, and as one atomizer will easily hold this amount plus an equal volume of carbon tetrachloride, two atomizers are all that are required for each of the larger rooms. One atomizer is usually sufficient for small bedrooms, bathrooms, and halls. All the atomizers are connected to a single air

line which runs to the auxiliary tank and pressure tank placed just outside a downstairs window or outside door. Rubber tubing, of one-fourth inch inside diameter, with walls heavy enough to withstand a pressure of at least 15 pounds, should be used. In most houses the connections to the atomizers can be so arranged that an excessive amount of rubber tubing will not be necessary as, for instance, in the diagram shown in Figure 6.

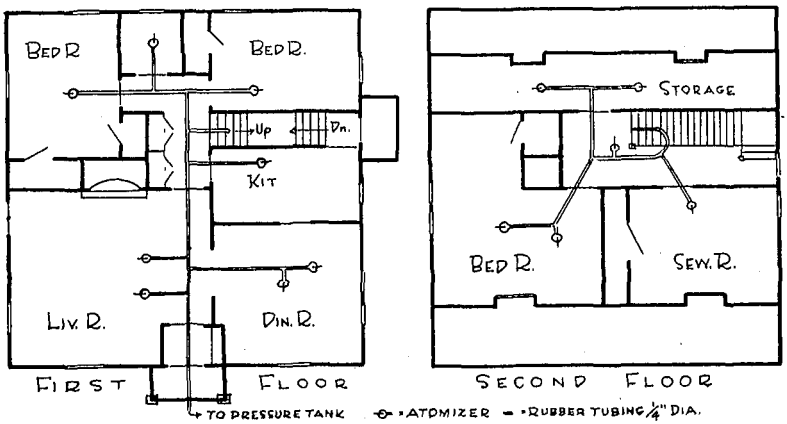

Fig. 6. Diagram of Two-Story House Showing Placing of Atomizers for the Application of Chlorpicrin

The atomizers, after being filled outdoors with the proper amounts of the fumigant for the different rooms, should be placed on the floor with several thicknesses of unfolded newspapers lengthwise directly ahead of each. If the tubing leading outside the house to the pressure tank is run through a window open slightly at the bottom, adhesive tape or thoroly wet newspaper should be used to plug up the openings at the bottom and between the two window sashes. A better way is to bore a three-eighths inch hole through the window sash to accommodate the tubing. Particular care should be used to see that all connections are tight and that there is no possibility of any of them blowing out before all the fumigant has been applied. The safest way is to wire or tie with cord all the connections.

In preparing the house for the fumigation, rugs should be raised from the floors by throwing them over chairs or other furniture. Clothing, extra bedding, and any other articles liable to insect infestation should be laid where they will be well exposed to the gas. House plants should be removed and all dry food, such as cereals, should be either removed or closed tightly in their containers.

It is very essential, on account of the heaviness of the chlorpicrin-carbon tetrachloride vapor, to close off the different floors from each

other. If there is no door by which the second floor can be closed off, a temporary partition of heavy wrapping paper should be erected. An easy way to put up such a partition is to select the narrowest place in the stairway and cut the paper just large enough that it can be held in place by several tacks at the top and sides. It can then be sealed tight with adhesive tape which will not leave any marks on the walls when the partition is removed. If the spaces beneath the doors upstairs are large enough to allow the tubing to pass under, the door should be closed after the rooms have been prepared and the atomizers are in place. Cracks around the outside doors and windows should be closed with wet paper. The door leading to the cellar should be closed tightly even if the cellar is also to be fumigated.

When everything is in readiness the pressure can be applied gradually to the atomizers until a pressure in the auxiliary tank of 12 to 15 pounds is registered. This pressure should be maintained until all the atomizers are empty. The time can be determined by looking in the downstairs windows and observing when the last of the liquid has been atomized.

The house should be kept closed for 12 hours. Then the doors and windows can be opened and the rooms allowed to air. When the equipment is removed, any small amounts of the fumigant remaining in the atomizers should be disposed of. So much of the chlorpicrin seems to be retained by bedding and clothing, that such articles should be carried outdoors as soon as possible and hung on a line where they will be freed of the gas much quicker than if left indoors. If the weather is cool the house can be aired in a shorter time if a good furnace fire is maintained and the windows are kept just partly open.

If the fumigation is started in the evening and allowed to proceed through the night, and if the weather is such that all bedding and clothing can be aired outdoors, the house can be occupied the first night after the fumigation. But if the weather is cool and damp the house will not be fit for occupancy until the second night. The difficulty of removing the chlorpicrin after the fumigation is one of its disadvantages, but most housekeepers who have been waging a losing fight against carpet beetles and clothes moths are perfectly willing to vacate the house for two nights if it can be successfully rid of such insects.

A chlorpicrin fumigation can not be carried out in any part of a house of which any other part must be occupied. Furthermore, an overnight fumigation with chlorpicrin should not be performed if the sleeping rooms of a neighboring house are very close to the house being fumigated. In this case it would be best to start the fumigation in the morning and have the house fairly well aired before night.

SUMMARY

1. In flour and cereal mills chlorpicrin is a very effective fumigant against localized infestations of insect pests. It can be used inside such milling machinery as elevator legs, grinding rolls, purifiers, certain kinds of dusters, bins, and tanks.

2. In the milling machinery it can be most effectively applied by atomizing it into the heads of the elevators. In bins and tanks it can be poured on sacks hung in the top openings.

3. When chlorpicrin is applied at the elevator heads and the mill is operated during the process, 5 pounds of chlorpicin should be used for each 1000 cubic feet of space to be fumigated. That is, the volume of all the machinery connected to the elevators in which the fumigant is to be applied is calculated and the quantity required is divided equally among the atomizers. In bins and tanks 2 pounds per 1000 cubic feet of space is sufficient.

4. Modifications of the methods given can be made to suit particular needs. Places most subject to infestation should be fumigated every two weeks. Such a practice will keep insects down to a minimum and obviate much of the old difficulty arising from the clogging of spouts and machines by the webs of the Mediterranean flour moth larvae.

5. The milling equipment must be made as tight as possible in order to confine the gas long enough for a successful fumigation. As this condition is in accordance with the best milling practice anyway, it is no particular prerequisite to the use of chlorpicrin.

6. Chlorpicrin fumigation is an effective control measure for clothes moths which attack upholstered furniture.

7. Chlorpicrin can be applied in furniture fumigation, (1) by air from a pressure tank used to force the chlorpicrin from a small chamber into the fumigation room where it is atomized by disk-type nozzles, (2) by a hand-operated compressed-air sprayer, the person doing the work being protected by a gas mask, or (3) by atomizers operated and controlled from a pressure tank outside the fumigation room. The last method is the most satisfactory.

8. In furniture fumigation the chlorpicrin should be used at the rate of 2 pounds per 1000 cubic feet of space in the room where the furniture is treated.

9. Chlorpicrin can be successfully applied as a fumigant for dwelling houses, and is particularly effective against clothes moths and carpet beetles.

10. The method of application in houses consists in distributing throughout the house atomizers which are all operated and controlled from a tank of compressed air stationed outside the house. One and one-fourth pounds of chlorpicrin is used per 1000 cubic feet of space in the house.

11. In all cases in which the clorpicrin is applied by means of atomizers, or when it is desired to get the chlorpicrin from the liquid state into the gaseous state quickly, it should be diluted with an equal quantity by volume of carbon tetrachloride.